Advancements Made In Commercial Real Estate Analysis and Pricing

Volume 1 of 2

by

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I confirm that the word count of this thesis is less than 20,000.

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DECLARATION

This thesis has been prepared to meet the requirements of a Doctor of Philosophy by publication degree at the University of Ulster.

I declare that this thesis represents my work, except where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for a degree, diploma or other qualification.

All possible care has been taken in the preparation of the information in this thesis; however, I expressly disclaim any liability for the accuracy and sufficiency of the information and under no circumstances shall either be liable in negligence or otherwise in and arising out of the preparation or supply of the information in this thesis.

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I would particularly like to thank Professor Sotiris Tsolacos, who first got me interested in real estate and with whom many ideas and papers then flowed.

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Finally, and most importantly, I would like to thank my parents and wider family. They brought me up with an enquiring mind and taught me well. Their unquestioning love and support got me here.

PAPERS USED IN THE SUBMISSION

Paper 1 - Connell-Variy T. and McGough T., (2020) "An examination of house price movements in Australian resource communities", paper submitted and presented in the referred section of the 26th Pacific Rim Real Estate Society Conference, Canberra, Australia.

Paper 2 - D'Arcy E., McGough T. and Tsolacos S., (1997a) "An empirical investigation of retail rents in five European cities", *Journal of Property Valuation and Investment*, **15** (4), p308-322. **Highly Commended by Emerald Publishing.**

Paper 3 - D'Arcy E., McGough T. and Tsolacos S., (1997b) "National economic trends, market size and city growth effects on European office rents", *Journal of Property Research*, **14**(4), p297-308.

Paper 4 - D'Arcy E., McGough T. and Tsolacos S., (1999) "An econometric analysis of forecasts of the office rental cycle in the Dublin area", *Journal of Property Research*, **16**(4), p309-21.

Paper 5 - Henneberry J., McGough T. and Mouzakis F. (2003) "The Economic Consequences of Planning for Business: Planning and Business Rents", *Final Report to the ODPM,* Department of Town and Regional Planning, University of Sheffield.

Paper 6 - Henneberry J., McGough T. and Mouzakis F. (2005) "The Impact of Planning on Local Business Rents", *Urban Studies*, **42(**3), p477-509. **Initial conference version of paper awarded the American Real Estate Society Foundation prize for the best paper presented at the European Real Estate Society 2003 conference in any area of real estate research.**

Paper 7 - McGough T. and Berry J., (2020a) "Pricing risk in yields and its impact on real estate market volatility", *Journal of Property Investment and Finance* (Forthcoming).

Paper 8 - McGough T. and Berry J., (2020b) "Pricing risk and its impact on real estate markets in Europe and Asia", paper submitted and presented in the referred section of the 26th Pacific Rim Real Estate Society Conference, Canberra, Australia.

Paper 9 - McGough T. and Tsolacos S., (1995b) "Property cycles in the UK: an empirical investigation of the stylised facts", *Journal of Property Finance*, **6**(4), p45-62.

Paper 10 - McGough T. and Tsolacos S., (1995c) "Forecasting commercial rental values in the UK using ARIMA models", *Journal of Property Valuation and Investment*, **13**(5), p5-21.

Paper 11 – McGough A. J. and Tsolacos S., (1997) "The stylised facts of the UK commercial building cycles", *Environment and Planning A*, **29**, p485-500.

Paper 12 – McGough T. and Tsolacos S., (1999) "Interactions within the office property cycle in Great Britain", *Journal of Real Estate Research*, **18**(1), p219-31.

Paper 13 – McGough T. and Tsolacos S., (2001) "Do Yields Reflect Property Market Fundamentals?" *City University Business School Real Estate Finance and Investment Research paper* No. 2001.01 March.

Paper 14 – McGough T., Tsolacos S. and Olkkonen O., (2000) "The predictability of office property returns in Helsinki", *Journal of Property Investment and Finance*, **18**(6), p565-585.

Paper 15 – Tsolacos S., Keogh G. and McGough T., (1998) "Modelling use, investment and development in the British office market", *Environment and Planning A*, **30**(8), p1409-27.

Paper 16 – Tsolacos S. and McGough T., (1999) "Rational expectations, uncertainty and cyclical activity in the British office market", *Urban Studies*, **36**(7), p1137-49.

Paper 17 – Tsolacos S., McGough T. and Thompson B., (2005) "Affordability and performance in the industrial property market", *Journal of Property Investment and Finance*, **23**(4), p311-328.

Examples of Private sector papers for consideration

Paper 18 – McGough, T. and Burston, B., (2009) "DTZ's Fair Value Estimates – Methodology and example", https://www.propertyweek.com/dtzs-fair-value-estimates-methodology-and-example/3148112.article

BCA Research Reports

Paper 19 – BCA Research Global Real Estate Strategy May 2013 - Stable Income, Right Price.

Paper 20 – BCA Research Global Real Estate Strategy February 2014 – One Rate to Rule Them All

ABSTRACT

This submission presents some of the author's published works over the period 1995-2020. They are presented in a way to show the development of a critical thought timeline. It starts with the initial analysis of the basics of a property cycle. It then develops by considering the author's work in examining, and indeed defining the analysis of domestic and then international models of the commercial real estate market. The author's research then expands in to the examination of international pricing of real estate investments. This is followed by considering comparative pricing versus other assets. It then considers the position of capital market risks and properties relationship with it as a core investment asset.

Through this presentation of the work, the submission aims to illustrate the author's continued position as a cutting-edge developer of original models and analysis of commercial real estate. It highlights the author's impact in the field and his continued work and relevance in these volatile times.

APPENDIX OF DATA SOURCES AND MNEMONIC MEANINGS USED WITHIN THE SUBMISSION

Chapter 2 - McGough & Tsolacos, 1997

Data definitions and sources

OFFO: Value of contractors' office building output (private sector) net of infrastructure at constant prices (deflated by the implicit GDP deflator). Source: *Housing and Construction Statistics* (HMSO, London)

INDO: Value of contractors' industrial building output (private sector) net of infrastructure at constant prices (deflated by the implicit GDP deflator). Source: *Housing and Construction Statistics* (HMSO, London)

RETO: Value of contractors' retail building output (private sector) net of infrastructure at constant prices (deflated by the implicit GDP deflator). Source: *Housing and Construction Statistics* (HMSO, London)

GDP: Gross Domestic Product at constant prices. Source: *Datastream*

TBL: Treasury bill in real terms (nominal rate-inflation rate). Source: *Financial Statistics* (HMSO, London)

GIL: Yield on ten-year gilts in real terms (nominal rate-inflation rate). Source: *Financial Statistics* (HMSO, London)

SHP: Price index of industrial 500 shares in real terms. Source: *Datastream*

SLI: Shorter leading indicator. Source: *Datastream*

LLI: Longer leading indicator. Source: *Datastream*

PRF: Gross trading profits of commercial and financial institutions at constant prices. Source: *Datastream*

BFO: Output of business and finance at constant prices. Source: *Datastream*

BSO: Service sector GDP at constant prices. Source: *Datastream*

SER: Service sector employment (classes 6–9). Source: *Employment Gazette* (Employment Department, London)

BFI: Employment in banking, insurance, and finance (classes 81–85). Source: *Employment Gazette* (Employment Department, London)

MFO: Volume of manufacturing output. Source: *Economic Trends* (HMSO, London)

EMP: Manufacturing employment (classes 2–4). Source: *Datastream*

EXP: UK consumers expenditure at constant prices, seasonally adjusted. Source: *Datastream*

RSI: Volume of retail sales index, seasonally adjusted. Source: *Datastream*

INC: UK total personal disposable income at constant prices, seasonally adjusted. Source: *Datastream*

RENO: Office rents at constant prices (deflated by the GDP implicit deflator). Source: *Jones Lang Wootton* London

RENI: Industrial rents at constant prices (deflated by the GDP implicit deflator). Source: *Jones Lang Wootton* London

RENR: Retail rents at constant prices (deflated by the GDP implict deflator). Source: *Jones Lang Wootton* London

CVO: Office capital values at constant prices (deflated by the GDP implicit deflator). Source: *Jones Lang Wootton* London

CVI: Industrial capital values at constant prices (deflated by the GDP implicit deflator). Source: *Jones Lang Wootton* London

CVR: Retail capital values at constant prices (deflated by the GDP implicit deflator). Source : *Jones Lang Wootton* London

AVF: Availability of vacant industrial floorspace. Source: *King and Sturge* London

Chapter 2 - McGough & Tsolacos, 1997

Data definitions and sources

OBC: Office building construction (private sector) value of new office building output, which represents new additions converted in real terms (deflated by the GDP implicit price deflator). Source: *Housing and Construction Statistics.*

SSO: Service sector output at constant prices. Source: *Datastream International*.

TBR: Interest rates, measured by the Treasury Bill are converted in to real terms by subtracting the year on rate of inflation at each quarter from the quarterly nominal interest rates Source *Datastream International*.

EBFI: Employment in banking-finance-insurance. Source: *Datastream International*.

ORS: Index of office rents (deflated by the GDP implicit price deflator). Source: *CB-Hillier Parker International*

Chapter 4 - D'Arcy, McGough and Tsolacos, 1997a

Data definitions and sources

RENT: Index of retail rents deflated by the GDP implicit deflator of each country; 1990 = 100. Source:*Jones Lang Wootton*.

GDP: Gross domestic product in constant prices in each country's own currency; 1990 = 100. Source: *Datastream*.

EX: Measure of consumer expenditure in constant terms, UK – consumer expenditure on non-durables, France – consumer expenditure on non-durables, The Netherlands – total household expenditure, Germany – total consumer expenditure Source: *Datastrea*m.

RS: Value of retail sales in constant terms; 1990 = 100. Source: *Datastream*.

Chapter 5 McGough and Berry, 2020b

Variable		**Source**
European Office Yields		Cushman & Wakefield
Cities initially looked at		Brussels, Leeds, London (City), Marseille, Paris,
Asian Office Yields*		Cushman & Wakefield and Knight Frank
Cities initially looked at		Melbourne, Shanghai, Singapore, Sydney
European and Asian GDP (GDP)		Oxford Economics
European and Asian Finance & Business/Services Output (FBO)		Oxford Economics
European and Asian Inflation (Inf)		Oxford Economics
European and Asian 10 Year Government Bonds (GB)		Oxford Economics
Risk Multipliers		
UK, German, US, Asia 5 Year Government Bonds		Oxford Economics/Bloomberg
UK, US, Europe, Asia 5 Yr Corporate Bonds		
Various Grades		Bloomberg/Oxford Economics
Calculation of Multipliers		Cushman & Wakefield/ Authors

Chapter 1 – Overview - Outline of the timeline and summary of the contribution and impact made by the author's papers

The PhD by published works proposal being submitted will show how this collected work has helped develop the area of commercial real estate market analysis, investment and forecasting. Through this portfolio of work, advances have been made in models developed and in the analysis of investment market pricing for property, both in its own right, and relative to other asset classes (notably bonds).

From the first research presented and paper published (**McGough and Tsolacos, 1995a** and **1995b**) the initial concern was to understand and correlate the basic fundamentals of how the market functioned and obtain orders of magnitude and timing influences on commercial real estate. Initially this was based around the workings of the real estate cycles. This work filled in gaps in both evidence-based analysis – people knew about cycles but did little to measure them - and then continued to clearly and correctly measure these linkages, correcting previous errors and omissions in modelling, by applying updated econometric knowledge and using better software/computer power.

This analysis also overflowed into the consideration of lagging and auto-correlation issues when modelling and forecasting real estate and provided modelling solutions to the issue of serial correlation being present in valuation-based data bases (**McGough and Tsolacos, 1995c**).

The papers then show a clear thread of development through market analysis to a detailed view of how the market interacts at local level (**Tsolacos, Keogh and McGough, 1998**). This was later developed into a more intricate analysis of government policy and its implications for local economies and the real estate market, culminating in work for the Office of the Deputy Prime Minister and award-winning papers in the area of micro/macro combined modelling (**Henneberry, McGough and Mouzakis, 2003 and 2005**).

While analysing some of the minutiae of micro and macro interaction, work continued on development of the fundamental knowledge of how the real estate markets worked. This was expanded into the building cycle (**McGough and Tsolacos, 1997, Tsolacos, Keogh and McGough, 1998**), together with specific analysis of different property

sectors. Much of the work was based around the office and to a lesser extent, the retail sectors (see referenced papers throughout this submission). However, there was work published on the industrial sector which also fell into this category (**Tsolacos, McGough and Thompson, 2005**).

Forecasting and modelling work was then expanded out to cities nationally (for example **McGough and Tsolacos, 1999**) and internationally (**D'Arcy, McGough and Tsolacos, 1997a and b; D'Arcy, McGough and Tsolacos, 1999** and **McGough, Tsolacos and Olkkonen, 2000**). This was done partially to compare modelling and market similarities and differences in an international framework, together with aiming to improve forecasting capabilities within the area of commercial real estate. In particular, analysis was included to take into account the different characteristics of cities and markets in different countries (**D'Arcy, McGough and Tsolacos, 1997a and b**). It will be shown how this developed a coherent framework for analysing the demand side and the fundamentals of rental drivers within real estate.

It will be illustrated how, simultaneously, there was a move to develop capital market analysis to look at the fundamentals of pricing. Though much of this was done within the private sector, some evidence of this is publicly available (for example the widely quoted **McGough and Tsolacos, 2001**).

The overall effect of this was to further the knowledge of the expected performance of commercial real estate as an investment asset class and provide some certainty when investors were making investment decisions. This was expanded further by covering behavioural analysis, concerning for example rational expectations (**Tsolacos and McGough, 1999**).

These areas were further advanced, developed and completed in an applicative form in the private sector. With private sector resources a fully functioning global forecasting framework was produced. Combined with further analytical improvements this morphed into the 'Fair Value Analysis' which was developed at Debenham, Thouard, Zadelhoff (known as DTZ and now part of Cushman and Wakefield, a real estate services company), and was widely reported, including on the front page of the FT (Thomas D., 2009, Pg. 1). The Fair Value Index brought together the pricing and forecasting of international real estate, together with the comparative analysis with government bonds. It resulted in the first publicly presented and regularly updated

analysis of the relative pricing of commercial real estate markets throughout the world and across property sectors. The methodology was published widely (**McGough and Burston 2009**) as well as contributing to many reports and other analysis in the private sector, which will also be discussed to some degree within this submission.

This work has been developed and expanded using other financial techniques to devise additional analysis of real estate investment markets. Some examples of this will be produced which, though not referred as they were private sector reports[1], will illustrate continued development of the thought process around modelling and understanding real estate investment markets. They will also show a continuing drive to look at pricing issues as markets have developed post the Global Financial Crisis (GFC).

Finally, it will be shown that the author continues to develop and analyse the area through published research (**McGough and Berry, 2020a**) and recent refereed conference articles (**McGough and Berry, 2020b**). This area has moved primarily into the analysis of the after effects of the GFC on real estate pricing and the impact it has had on the relationship with government bonds. This leads consequently to the changing 'known' relationship with the wider economic and financial market. As many government bonds have fallen to historic lows and some turned negative, the impact of this on real estate markets, and even on the aforementioned, long known relationships which have been studied over the last few decades, are being questioned again. At the same time the author continues to work on new market specifics in previously unexamined areas of real estate (**Connell-Variy and McGough, 2020**).

In short, this submission will illustrate how the papers published and research carried out show a consistent path into the development of quantitated facts and proofs concerning the issue of what influences the commercial real estate investment market, its interaction with the demand and supply side of the economy, as well as capital markets. It will also show the development of forecasting methodologies incorporating the stylised facts that were revealed in the author's early work, as well as including allowances for different sector and locational factors. This work will be shown to have then developed an innovative and highly regarded comparative pricing model incorporating real estate's relationship to other asset classes and the impact of risk on

[1] Published while Chief Strategist in Global Real Estate at BCA Research which as a pure research house sold only research at a considerable premium into the market.

real estate; a model still in use today in the private sector. Finally, it will be shown how this research continues to this day in the analysis of the pricing of risk and shock effects like the GFC and the after effects of quantitative easing.

The remaining chapters will proceed as follows. Chapter 2 will consider the author's portfolio of work in relation to the stylised facts of the commercial real estate market. Chapter 3 will consider the author's work in advancing our knowledge of modelling individual markets and the influencing factors on them in the UK. Chapter 4 expands this work into the international arena and highlights work in developing models in other countries. Chapter 5 looks at the author's work developing market knowledge in pricing and investment, particularly yield modelling and asset price comparisons. Finally, Chapter 6 will conclude the submission and discuss forthcoming work by the author.

Chapter 2 – Advancements in the Knowledge of the Stylised Facts of the Commercial Real Estate Market and Property Cycle Research

Property Publications in this chapter.

The following papers are submitted in this chapter concerning property stylised facts and cycles:

Paper 9 – McGough T. and Tsolacos S., (1995b) "Property cycles in the UK: an empirical investigation of the stylised facts", *Journal of Property Finance*, **6**(4), p45-62.

Paper 10 – McGough T. and Tsolacos S., (1995c) "Forecasting commercial rental values in the UK using ARIMA models", *Journal of Property Valuation and Investment*, **13**(5), p5-21.

Paper 11 – McGough A. J. and Tsolacos S., (1997) "The stylised facts of the UK commercial building cycles", *Environment and Planning A*, **29**, p485-500.

Paper 12 – McGough T. and Tsolacos S., (1999) "Interactions within the office property cycle in Great Britain", *Journal of Real Estate Research*, **18**(1), p219-31.

Chapter 2.1 Initial analysis of property cycles.

With the advancement in computer technology in the late 1980s and early 1990s together with the increased availability and quality of data new opportunities to analyse real estate arose. Property cycles had been a 'known fact' for some time but little had been done to actually quantify the cycles. Some analyse of cycles had already taken place, notably in the U.S. Bischoff (1970) and Rosen (1984) had built models which looked at office construction while Wheaton and Torto (1992) had created a model of US industrial development. These papers covered models of the markets, and as such, they did not set out to or actually cover the pure cyclical element of property but looked at the cycles more indirectly through econometric models.

In the UK, Barras and Ferguson (1987 a and b) showed some positive correlations with industrial rents. Key *et al* (1994) discussed the cycles in a theoretical paper and this was expanded into a model of regional construction by Keogh (1994) showing regional offices were best modelled by office rents and capital values. However, these papers also looked at the quantitative models to imply drivers of the market and not the cycle itself.

At the RICS Cutting Edge Conference **McGough and Tsolacos (1995a)** first presented the idea of fully analysing the stylised facts of the property market. This was developed into a fuller paper (**McGough and Tsolacos, 1995b**) and further expanded in **McGough and Tsolacos (1997)**. Using contemporary business cycle literature such as Brandner and Neusser (1992) the paper incorporated the use of a methodology created by Hodrick and Prescott (1980) known as the Hodrick Prescott (HP) filter to capture the cyclical component of the office, retail and industrial sector This made the assumption that there was a trend level of growth in any variable, and around this the cyclical growth flowed (summing to zero). The paper then created a Lagrangian equation, with the rule that the square of the cyclical part of a variable is minimized, subject to a smooth growth rate. This provide the equation below, where:

c = the cyclical component;
G = the trend component of any variable Y;
where:
$Y_t = c_t + g_t$
This technique allowed the extraction of the actual cycle as shown in an example of the office building output cycle in Figure 1.

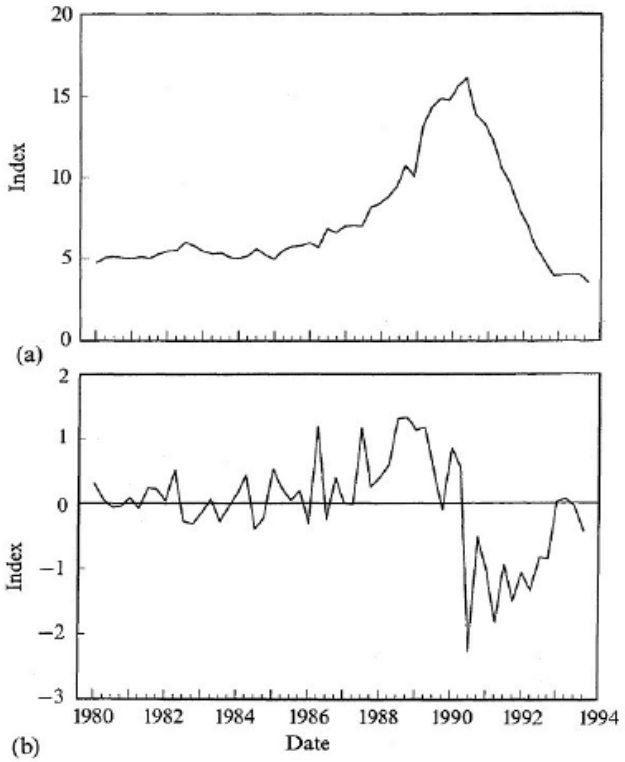


Figure 1. (a) Office-building output; (b) cyclical component of office-building output.

Source: McGough and Tsolacos, 1997

This enabled **McGough and Tsolacos (1997)** to provide a full analysis of the property cycle. The areas to examine were spelt out in the paper as certain properties in relation to:

- Amplitude or volatility of fluctuations of the variable;
- Persistence of the variable, in terms of the tendency of its changes to persist over time before reverting to the long-term trend;
- Procyclicality of the variable; that is whether the variable tends to conform with the different phases of the reference cycle (rise in the upward phase and fall in the downward phase);
- Countercyclicality of the variable; regarding the tendency of the variable to move inversely to the reference cycle (fall in the upward phase and rise in the downward phase). (Hodrick and Prescott, 1980)

McGough and Tsolacos (1995b) then went on to fully analyse the UK cyclical component and its relationship to major economic variables for all three commercial sectors (office, retail and industrial) for the first time.

Following further statistical tests to check the veracity of the data, a full set of correlation coefficients was created to show the full cyclical relationship as shown in an example in Table 1. This table visually illustrates the leading and lagging relationships between, in this example, office building and other economic and financial variables within a property cycle. The increase in construction lagged banking, finance and services output, and more generically GDP. It highlighted the specific service and finance variables that were more important than GDP per sae. The impact of growth in capital values (CVO) on office construction peaked with a two-period lag. Though much of this had been presumed, in this table it was writ large. The paper repeated this for the retail and industrial sector spelling out for the first time the timings and magnitudes of cyclical relationships as revealed by the econometric modelling.

Table 1. Cross-Correlation with office building output at time t

	$t-7$	$t-6$	$t-5$	$t-4$	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$
GDP	0.27	0.39	0.35	0.38	0.38	0.44	0.45	0.24	0.20	0.11	0.13
BSO	0.40	0.33	0.41	0.42	0.33	0.46	0.44	0.08	0.26	0.29	0.10
BFO	0.47	0.34	0.47	0.49	0.40	0.54	0.50	0.24	0.42	0.37	0.22
SER	0.12	0.25	0.24	0.33	0.38	0.45	0.36	0.44	0.40	0.21	0.30
BFI	0.23	0.32	0.41	0.55	0.55	0.52	0.58	0.61	0.37	0.31	0.27
PRF	0.18	0.18	0.18	0.08	0.25	0.08	0.03	0.13	−0.07	−0.11	0.07
SHP	0.12	0.10	−0.05	−0.01	0.09	0.10	0.04	−0.13	0.18	0.01	−0.11
TBL	−0.17	−0.08	0.03	0.05	0.08	0.15	0.15	−0.01	0.19	0.05	0.06
GIL	−0.22	−0.15	0.01	−0.02	−0.08	0.02	0.01	−0.13	0.10	−0.09	−0.02
RENO	0.05	0.27	0.37	0.45	0.50	0.62	0.75	0.69	0.70	0.66	0.54
CVO	0.17	0.39	0.52	0.57	0.58	0.70	0.63	0.55	0.49	0.26	0.16
SLI	0.16	0.24	0.31	0.37	0.40	0.46	0.46	0.39	0.27	0.20	0.18
LLI	0.48	0.50	0.49	0.43	0.35	0.28	0.16	0.05	−0.02	−0.13	−0.20

Source: McGough and Tsolacos, 1997

Finally, **McGough and Tsolacos (1997)** further enhanced the work by the analysis of structural breaks, using Chow Tests, to confirm the stability of the long-term cyclical relationship in the retail and industrial sector and highlight issues concerning the office sector around 1990 (possibly linked to the big bang and the recession in the late 1980s).

Chapter 2.1.1 The significance of Chapter 2.1

The articles thus built on adapted methodology from the modern business cycle research found in the economics and finance fields and applied it to the commercial real estate market. They examined the cyclical regularities of certain independent economic variables relative to office, industrial and retail property cycles. By examining the cross-correlations and co-movements, the cyclical properties of the commercial real estate market were exposed.

The papers also highlighted the issue of detrending within the real estate market – notorious for its auto-correlated indices - and the different techniques used to filter data and derive the cyclical component of the series used, before cross-correlations were estimated.

More importantly, the articles set up a base of information concerning the real estate market and the fundamentals of the drivers within it. They also illustrated future research avenues which real property market analysts began studying

within real estate cycles. The papers highlighted the need to consider and compare other detrending techniques and compare the results. They also pointed out the need to investigate the cyclical properties of other variables and over longer sample periods. Finally, the papers raised the issue of applying the analysis across countries and attempting to identify similarities in the cyclical behaviour of certain variables over the property cycles.

To put it simply:

> ***'The notion of the "stylised facts" plays an important role in macroeconomics. One may even say that it serves the field, in the sense that stylised facts describe what phenomena are to be explained by theoretical modelling'***
> ***(Brandner and Neusser, 1992, p. 67).***

Chapter 2.2 Further work on cycles and modelling techniques

Several other techniques for modelling and analysing the UK market were looked at. As discussed **in McGough and Tsolacos (1995b)**, Beveridge and Nelson (1981) had considered using Auto Regressive Integrated Moving Average (ARIMA) systems to analyse cycles and in **McGough and Tsolacos (1995c)** such an ARIMA model was used to not just analyse the cycle but provide short term forecasts. After analysing the basic trends in the office, retail and industrial markets, a time series ARIMA (ρ, d, q) model was built, the general form of which was:

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots + \beta_\rho y_{t-\rho} + \theta_0 + \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots - \theta_q \varepsilon_{t-q}$$

- $y_t = \Delta^d Y_t$;
- Δd = the d^{th} difference of variable Y at time t;
- Thus d = the degree of integration;
- θ_0 = a constant;
- ε = the error term;
- ρ = number of lagged terms of y_t; and
- q = the number of lagged terms of ε.

Source: McGough and Tsolacos, 1995c

The modelling data was robustly tested for stationarity (Augmented Dickey-Fuller test), lag length – via the analysis of autocorrelation and partial autocorrelation tests (ACF and PACF) and seasonality using an adapted HEGY test (Hyellberg-

Engle-Granger-Yoo, 1990). A full set of descriptive tests and three fully defined and tested ARIMA models were produced for the first time for UK real estate by **McGough and Tsolacos (1995c)** in this paper. By looking at an ARIMA system the authors were able to compare the impact of past changes versus shocks to help explain the movement in rents.

The results in **McGough and Tsolacos (1995c)** indicated that for the retail sector past changes in the values of rents influenced current and future changes and that the most recent changes were the most influential. For office rents, it was past shocks which affected present and future changes in rental values. Finally, changes in industrial rents displayed a pattern similar to that for changes in retail rents, though with a longer time horizon (spanning three periods in the past).

The implications of **McGough and Tsolacos (1995c)** were more wide spread than a simple forecasting model. With the robust analysis of the database being used, it provided clear implications for the specification of general structural models. Also, the models provided useful insights into the market and rent movements for short-term investors, particularly for the forecasting of turning points. The models also helped capture the trends easily and without the intensive use of data. This was an important factor given the limited databases for real estate at the time. Furthermore, the information gleaned from **McGough and Tsolacos (1995)'s** paper could be and was used by other authors in conjunction with other model specifications to develop the field further.

Further analysis of property cycles in the UK came from **McGough and Tsolacos (1999)**. This paper used a vector autoregressive model (VAR), as used by Kling and McCue (1987) who studied office markets in the US to analyse the UK market. This model was an extension of the autoregressive model as used in **McGough and Tsolacos (1995c)**. It incorporates other variables to interact within the autoregressive system to provide a fuller picture of the market and used the equation below:

$$Y_t = B_0 + B_1 Y_{t-1} + B_2 Y_{t-2} + \ldots + B_n Y_{t-n} + e_t,$$

where Y is a vector of all variables used in the equations, B_0 is the n x 1 vector of intercept terms, B_s are the n x n matrices of coefficients that relate lagged values of

the variables to their current values, n is the desired lag length and e_t is the vector of errors that are uncorrelated with their own lagged values and with Y_{t-1} through Y_{t-n}.

Once again, robust initial analysis of the dependent and independent variables was carried out in **McGough and Tsolacos (1999)** before modelling commenced. Granger Causality tests were carried out on the data (Table 2) to analyse the direction of flow of information within the vector of variables. The table below helped explain which variables had causal relationships and thus were most useful for modelling office building output and the broader property cycle. It also explained those with a relationship, or indeed moved, because of the property cycle.

Table 2. Granger Causality Results

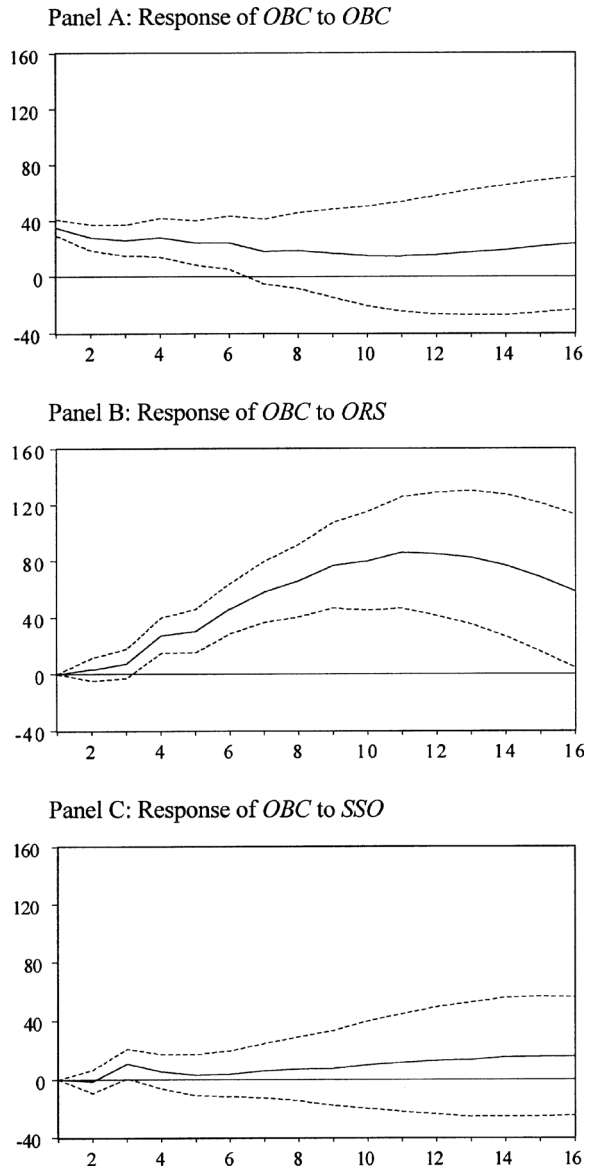
Null Hypothesis	*F*-Statistic
H_0: *ORS* does not cause *OBC*	11.54
H_0: *OBC* does not cause *ORS*	0.75
H_0: *SSO* does not cause *OBC*	3.86
H_0: *OBC* does not cause *SSO*	2.01
H_0: *EBFI* does not cause *OBC*	1.55
H_0: *OBC* does not cause *EBFI*	1.42
H_0: *TBR* does not cause *OBC*	0.21
H_0: *OBC* does not cause *TBR*	0.41

Note: The number of lags is 4. The critical value $F(4,56) = 2.46$; the sample period is 1980:2–1996:4.
OBC = Volume of office building construction.
ORS = Real office rents.
SSO = Volume of service sector output.
EBFI = Employment in banking-finance and insurance.
TBR = Real Treasury Bill rate.

Source: McGough and Tsolacos, 1999

Following on from this a VAR model was successfully set up to analyze the cyclical relationship. The cyclical composition was once again confirmed and through the VAR model the interaction between the economy and property observed. This led to the ability to provide impulse effect charts, which showed the short to medium term response of office construction to changes in other variables (see Figure 2).

Figure 2. Analysis of Impulse Responses for Office Building Construction



Source: McGough and Tsolacos, 1999

The objective of **McGough and Tsolacos (1999)** was to once again further extend the existing, rather limited empirical treatment of office cycles. The study followed a VAR methodology to examine the office cycle proxied by the volume of office building construction. Within this framework, it was assumed that trends in office rental values, service sector output, employment in banking-finance-insurance and the real Treasury Bill rate would capture the movements of office construction in the UK across time. The Granger causality tests and VAR estimates established, however, that employment and the interest rate were variables that did not exert any notable direct influence on office development in the UK. This was a different result from that

obtained by some US studies in which employment variables have received strong empirical support. Kling and McCue (1987) had also argued that, with regard to interest rates, they affected office construction through their effect on output. It was postulated in the paper that these effects may have been absorbed within the rental data.

The study of the dynamics of the VAR model of office development within **McGough and Tsolacos (1999)** was based on a decomposition of historical deviations of the actual office construction values from a predicted trend, as well as looking at the decomposition of error terms from models forecasting the construction variable four years ahead. Also considered was the response to shocks that occurred to the variables. Office rents were found to be the main influencer on office construction. Given that the commercial office market is dominated by rented accommodation this made sense. New developments would be largely initiated by developers and/or investors when rents and total returns on the completed projects indicated a profitable development. The paper thus illustrated that office construction in the UK was driven by office rents since they carry information about demand and supply conditions in the market. They are thus a good proxy for the expected degree of profitability of new developments. The study of the responses of office building output to a shock in office rents also suggested that the supply response was inelastic in the first year but then office construction responded positively, and this reaction reached a maximum point after a period of nearly three years, highlighting property development illiquidity.

While many authors had noted the relevance of real estate cycles in the strategies of real estate market participants, **McGough and Tsolacos (1999)** showed that the rent cycle provided information about investment decision making that could be used to predict the cyclical behavior of office development, and so help to estimate its severity. It was highlighted that international property investors should note that relatively strict planning controls (which were to be looked at by **Henneberry, McGough and Mouzakis (2003, 2005**) and will be discussed in chapter 3) and lack of development land in the UK could hinder an effective response of the development industry to office demand pressures.

Chapter 2.2.1 The significance of Chapter 2.2

This chapter followed on from the identification and quantifying of a clear cyclical element as outlined in chapter 2.1. It developed models to build the cycle and show both the interaction of other economic variables on the real estate market and the lengths of lags that occurred in the market. It also illustrated techniques to successfully deal with trended data within real estate.

More importantly it showed the rich vein of research which was available with the understanding of how cycles work and what the driving forces of property in the UK were. It also highlighted the importance of this work to both investors, developers and government agents as well as, of course, occupiers. This increased interest further in the area of analysing, modelling and forecasting commercial real estate.

Chapter 2.3 The overall significance of this Chapter as a whole

The contribution of the author from these works was to illustrate the ability to develop robust models for real estate based around property cycles. This was facilitated by the increasing availability of quality data and, just as importantly, increased computer power. Consequently, econometric software became more powerful and faster. The author took full advantage of this to show the investment world what could be done in this environment.

The establishment of the stylised facts stream of papers finally put into words and numbers what had previously been observed but not rigorously tested and captured in a quantitative way. The impact of the models in chapter 2.2 was to show what uses this research could have. Creating models to forecast turning points in the market and estimate impacts of rental growth to construction for example. This raised the profile of quantitative real estate in the eyes of academia and investors. Such was the significance of the work, the author started a career oscillating between academia and the private sector, as the relevance of the research became clear to the investment world. This will become apparent when reading through the discussion within this submission as well as looking at the affiliation of the author on academic papers.

Chapter 3 - Modelling Factor Influences at Market Level in the UK

Property Publications in this chapter.

The following papers are submitted in this chapter concerning modelling markets in the UK:

Paper 5 – Henneberry J., McGough T. and Mouzakis F. (2003) "The Economic Consequences of Planning for Business: Planning and Business Rents", *Final Report to the ODPM,* Department of Town and Regional Planning, University of Sheffield.

Paper 6 – Henneberry J., McGough T. and Mouzakis F. (2005) "The Impact of Planning on Local Business Rents", *Urban Studies*, **42(**3), p477-509. **Initial conference version of paper awarded the American Real Estate Society Foundation prize for the best paper presented at the European Real Estate Society 2003 conference in any area of real estate research.**

Paper 15 – Tsolacos S., Keogh G. and McGough T., (1998) "Modelling use, investment and development in the British office market", *Environment and Planning A*, **30**(8), p1409-27.

Paper 16 – Tsolacos S. and McGough T., (1999) "Rational expectations, uncertainty and cyclical activity in the British office market", *Urban Studies*, **36**(7), p1137-49.

Paper 17 – Tsolacos S., McGough T. and Thompson B., (2005) "Affordability and performance in the industrial property market", *Journal of Property Investment and Finance*, **23**(4), p311-328.

Chapter 3.1 Modelling the UK commercial real estate markets

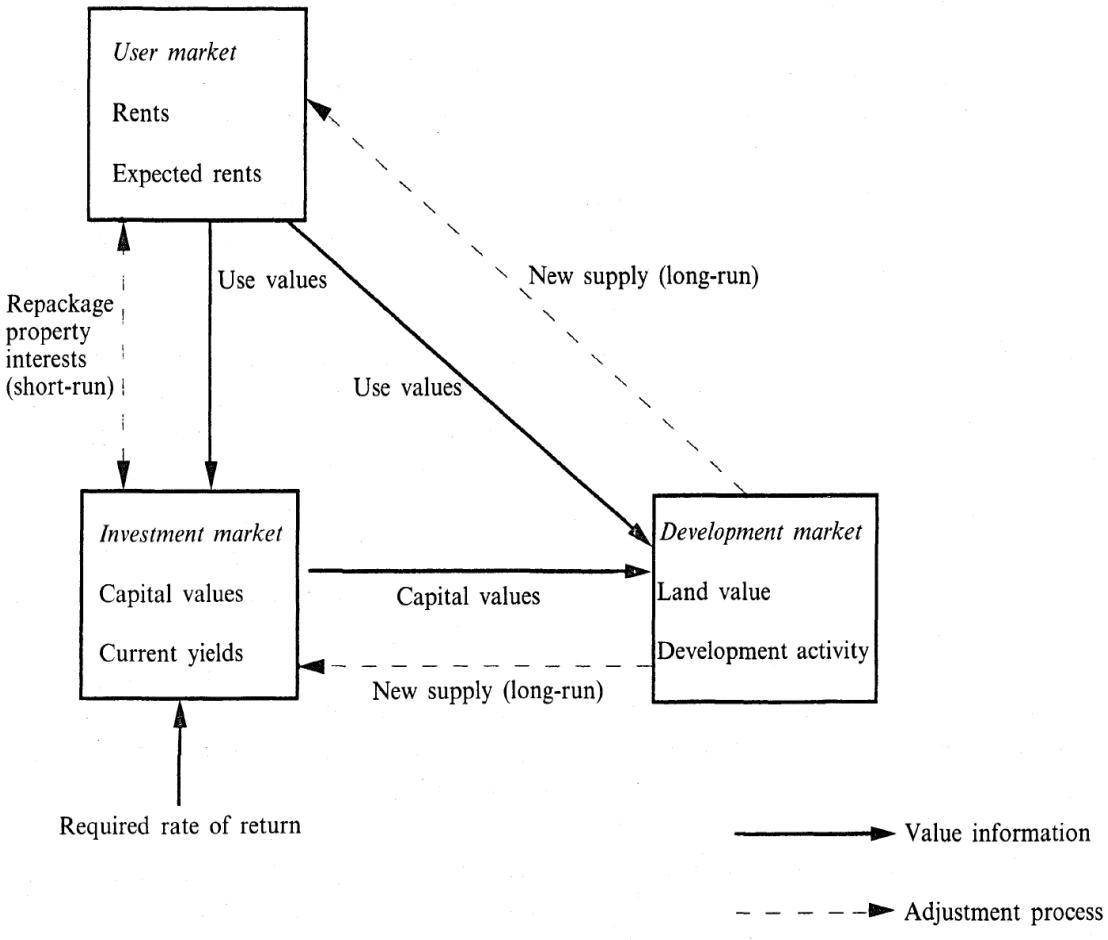
Following on from chapter 2, which looked at the development of modelling and forecasting the cyclical market in real estate, the author continued quantitative work on the actual workings of the commercial real estate market in the UK. An early piece of work by the author considered modelling development cycles in relation to investors (**Tsolacos, Keogh and McGough, 1998)**. With the author having moved to the private sector by this time, this work combined both academic rigour and an applicative nature to the work. It attempted to model the interactions and lags that lead to large swings in rents, together with under and over construction in the development market.

The interaction and dynamics of the office market had had some analysis in the US, for example Pollakowski *et al* (1992), but within Europe most market modelling have

concentrated on modelling rents (**McGough and Tsolacos, 1995c** and Key *et al* (1994)). Keogh (1994) had posited the idea of a three-tier model of the investor developer cycle. In **Tsolacos, Keogh and McGough (1998)** the author took previous theoretical work from Keogh (1994) and created an actual fully functioning, quantitative version.

Keogh's model, illustrated in Figure 3, explicitly looked at the drivers of the development market's key players. The three-equation model created in **Tsolacos, Keogh and McGough (1998)** showed this interaction in a quantifiable format. The user market was represented by rents, the developer market by construction, both of which were modelled in line with previous work by the author discussed in chapter 2. The investor market was incorporated by developing a model of capital values. The three equations follow on from Figure 3 in Figure 3a.

Figure 3. The driving forces and adjustment dynamics of the user, investment, and development markets.



Source: Keogh, 1994

Figure 3a. The driving forces and adjustment dynamics of the user, investment, and development markets modelled

Rent equation (user)

$$\Delta R_t = a_1 + \sum_{i=0}^{I} b_i \Delta V_{t-i}^{\mathrm{GDP}} + \sum_{j=0}^{J} \gamma_j \Delta E_{t-j}^{\mathrm{BFI}} - \sum_{k=0}^{K} w_k \Delta V_{t-k}^{\mathrm{OFBO}} + \varepsilon_{1t},$$

Capital Value equation (Investor)

$$\Delta V_t^{\mathrm{CV}} = a_2 + \sum_{s=0}^{S} v_s \Delta R_{t-s} + \sum_{m=0}^{M} p_m \Delta V_{t-m}^{\mathrm{SP}} - \sum_{q=0}^{Q} w_q \Delta V_{t-q}^{\mathrm{OFBO}} + \varepsilon_{2t}$$

Office building output (Developer)

$$\Delta V_t^{\mathrm{OFBO}} = a_3 + \sum_{n=0}^{N} s_n \Delta R_{t-n} + \sum_{\phi=0}^{\Phi} g_\phi \Delta V_{t-\phi}^{\mathrm{CV}} - \sum_{h=0}^{H} f_h r_{t-h}^{\mathrm{INT}} + \varepsilon_{3t}$$

Source: Tsolacos, Keogh and McGough, 1998

Tsolacos, Keogh and McGough (1998) explicitly acknowledged that office development was driven by the user market and so would itself respond to conditions in the real economy. The paper also acknowledged that trends in the wider investment market influenced property as an asset. The results also established the significance of the demand-side in the user market, although recognizing that, in certain periods, such as the early 1990s, supply-side factors could become relatively more important than demand-side forces. Finally, the three-equation model aimed to replicate conditions in the user, investment, and development markets.

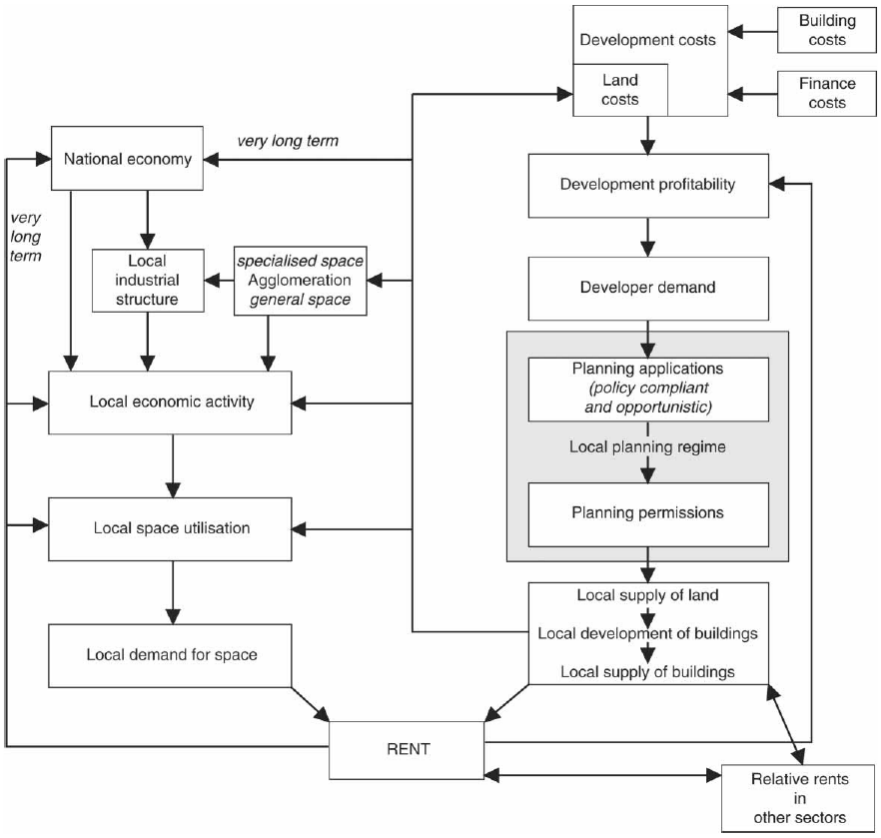
The paper provided interesting conclusions, particularly for the investment market i.e. office capital values. The speed of the adjustment of capital markets (rents lagged just 1 quarter were significant) implied the investment market reacts quickly to signals. The fact that short-term interest rates appeared significant in explaining changes in office capital values was an early indicator of future work by the author (**McGough and Tsolacos, 2001**) on the interaction of commercial property and other investment assets. Due to poor diagnostic tests at the time, it was concluded that the theory behind the study of the movements of office capital values (or office yields) needed to be developed more fully, so that alternative

dynamic specifications could be tested in future research. The paper thus provided directions for further research and development in the field.

The office development model, based on the Treasury Bill rate and changes in rental and capital values, provided results which captured the general trends in the adjustment of office development, but did not take into account the more volatile nature of finance. Changes in rental and capital values lagged by up to two periods were shown to be significant in the office building output. However, capital values were also relevant and provided earlier signals. This is in accordance with the author's previous findings (**McGough and Tsolacos, 1995b; 1997**) in which it was established that capital values tend to lead the office rent and the building cycles.

Continuing with analysis of the office market, the author in association with Henneberry applied and won a sizeable 2-year project from the Office of the Deputy Prime-Minister (ODPM). The resultant 100-page report, (**Henneberry, McGough and Mouzakis, 2003**) spawned a book chapter and an award-winning paper for best paper presented at the European Real Estate Society in 2003, (**Henneberry, McGough and Mouzakis, 2005**). The project's aim was to look at the impact of different planning regimes within the UK on the local economy. A model was created by the authors (Figure 4) with influences from the work of Bramley (1993a and b) on the supply side and Armstrong and Taylor (2000) on the demand side. The model incorporated agglomeration benefits and space utilization within towns, together with a unique measure of planning regime harshness developed by the authors. This contributed to a simplified 5-equation model of the market (Figure 5). Given how little work had been done on modelling planning regimes much of this was developed and created for the ODPM project from near first principles, with some assistance from government planning officers.

Figure 4. Sector-specific model of the local property market.



Source: Henneberry, McGough and Mouzakis 2005

Figure 5. Simplified 5 equation functional form of Figure 4

Demand

Local Economic Activity = f (+Industrial Structure, +Local Supply of Space, +Urbanisation Economies, +Localisation Economies, −Rent) **(i)**

Space Utilisation = f (+Rent, +Local Economic Activity, −Local Supply of Space) **(ii)**

Supply

Local Supply of Space = f (+Planning Applictions, +Planning Regime, −Relative Rents of Other Sectors) **(iii)**

Planning Applications = f (+Rents, −Costs, +Planning Regime, +Local Economic Activity) **(iv)**

Rent

Rent = f (+Local Economic Activity, −Space Utilisation, −Local Supply of Space, ±Relative Rents of Other Sectors) **(v)**

Source: Henneberry, McGough and Mouzakis 2005

This system became a first attempt to model the planning regime as it applies to commercial real estate, as virtually all previous work had been around residential markets. This model was cross-sectional in nature with the demand, supply and price variables presented at regional and national levels. Given there was no official measure of planning regimes, the planning system was articulated primarily through measures of the local implementation of policy within national and regional guidelines i.e. how harshly local councils implemented these policies measured by their rejection of planning applications.

Henneberry, McGough and Mouzakis (2003) identified a local effect of planning that was consistent with theory. The paper showed that, as planning regimes become tighter and the percentage of planning decisions that were approved decreases, so the local supply of space decreased. Lower levels of supply of space were also associated with less local economic activity and at the same time higher rents. Using data from 50 centers, across all three commercial sectors (provided by JLL) a thorough examination of the UK was carried out. Part of the impact depended on the existence and extent of spill-overs. Restrictive planning policies operating in one location would reduce the supply and increases the price of space for local businesses. Locational adjustment by firms - moving to other locations with more permissive planning regimes where there is more space at lower prices - would mitigate the impact of tighter planning regimes in other locations.

Henneberry, McGough and Mouzakis (2003) highlighted the fact that the characteristics of the system operating at the time were consistent with, and an outcome of the long-run operation of a stable pattern of local planning regimes. The results of the study represented a significant contribution to the development of a theoretically robust model for analyzing and estimating the effect of planning on the property sector of the local economy. Besides being an award-winning piece of research, the paper was well received by the ODPM. Furthermore, the paper was utilized by the Government to guide policy on the planning regime in the country and to advise local authorities.

Whilst having generally worked on the office and retail markets or all three main commercial markets as in the previous paper, the author also choose to explore more fully the industrial commercial property market in **Tsolacos, McGough and**

Thompson (2005). This paper aimed to drill down into the industrial sector to see if more valuable and useful data was available to use when modelling the sector, thus expanding our knowledge in one of the lesser reported areas of investment property. The aim of the paper was to go beyond the usual explanatory variables, such as GDP or manufacturing output. Moving on from this point, the paper assessed the significance of cash flow and profitability survey data in the modelling and forecasting of industrial rents. The data was taken from the British Chambers of Commerce regional surveys of the manufacturing sector and was used as a proxy for the affordability of industrial space for occupiers. This enabled the author to examine whether firm's general economic wellbeing and cashflow had an influence on rents.

Tsolacos, McGough and Thompson (2005) used a cross-section, time-series framework (similar to panel-data analysis) which looked across the regions of the UK through time. A model was created to analyse regional industrial rents using a set of output and employment variables. This was a two-stage process. A standard model using traditional variables was calculated first. This was then augmented with the inclusion of the cash flow and profitability measures from the British Chamber of Commerce.

Consequently 2 equations, shown below were modelled and compared.
The standard equation:

$$RENT_{j,t} = \alpha_j + \sum_{i=0}^{N} \beta_{1j,t-i} MFO_{j,t-i} + \sum_{i=0}^{N} \beta_{2j,t-i} GDP_{j,t-i} + \sum_{i=0}^{N} \beta_{3j,t-i} RENT_{j,t-i} + \varepsilon_t$$

and one incorporating financial wellbeing indicators:

$$RENT_{j,t} = \alpha_j + \sum_{i=0}^{N} \beta_{1j,t-i} MFO_{j,t-i} + \sum_{i=0}^{N} \beta_{2j,t-i} GDP_{j,t-i} + \sum_{i=0}^{N} \beta_{3j,t-i} RENT_{j,t-i} + \sum_{i=0}^{N} \beta_{4j,t-i} CF_{j,t-i} \sum_{i=0}^{N} \beta_{5j,t-i} PROF_{j,t-i} \sum_{i=0}^{N} \beta_{6j,t-i} TRV_{j,t-i} + \varepsilon_t$$

Source: Tsolacos, McGough and Thompson, 2005

Tsolacos, McGough and Thompson (2005) found that changes in real industrial rents were influenced by changes in output, which was consistent with the findings of studies at the time. Supportive evidence for turnover and profitability was found in four regions. On top of this some regions of the UK were influenced by other factors. Table 3 summarises the results. The table highlighted the areas in the UK where

improvements in models could be made by incorporating the extra explanatory variables discussed previously. This was particularly the case in London and Yorkshire and Humberside.

Table 3. Summary of Results

Region	Statistically significant indicator
Eastern	None
East Midlands	None
London	Changes in profitability (lagged four quarters) Changes in turnover (contemporaneous) Changes in cash flow (contemporaneous)
North	None
North West	Changes in profitability (lagged seven quarters)
South West	None
Wales	Changes in profitability (lagged four quarters)
West Midlands	None
Yorkshire and Humberside	Changes in profitability (contemporaneous) Changes in turnover (contemporaneous) Changes in cash flow (lagged seven quarters)

Source: Tsolacos, McGough and Thompson, 2005

Tsolacos, McGough and Thompson (2005) further extended the existing analysis on industrial rents by introducing variables which looked at direct turnover and profitability series. This implied that greater use of such series in property performance forecasting over short-term horizons had the potential of improving forecasting accuracy, thus resulting in smaller errors.

Finally, for this chapter of the submission, the author returns to examine the UK development cycle, but this time examined in relation to theoretical economic ideas on the running of markets and their efficiency. In ***Rational Expectations, Uncertainty and Cyclical Activity in the British Office Market*** (**Tsolacos and McGough, 1999**) the author examined how the markets incorporated uncertainty and historic information within the office development cycle.

Previously, much of the work on office development and cycles simply looked at economic influences (Wheaton *et al* 1997 and **McGough and Tsolacos, 1995b, 1997**) or concentrated on the natural vacancy rate (Rosen 1984). This paper wanted to examine specifically how the market worked and was explicitly concerned with how it learned from economic shocks and past events in the market as well as uncertainty in the market both economic and commercial rental uncertainty. The aim was to see if

the market behaved rationally, which would help investors and developers respond to future market events. The paper also wanted to see how it incorporated past lessons and so also tested for adapted expectations.

To test for rational expectations a clearly and correctly specified model had to be created (see **Tsolacos and McGough, 1999**) before tests were carried out for efficiency and consistency. The paper showed that changes in the level of output of service industries, changes in real office rents and uncertainty arising from the volatility of real office rents were significant variables in the model explaining the development cycle. A number of diagnostic tests established that the estimated model was well specified. As had been noted in previous papers, it was shown that office building development was positively related to trends in economic activities requiring office space. Building on this, the paper found that the volatility of rents in the 1990s, especially with the negative growth rates exhibited in the early 1990s, had a negative effect on the rate of office development. This provided a recommendation that in the econometric modelling of the office cycles the role of uncertainty needs to be considered as it may convey significant information in particular periods (this is returned to by the author in chapter 5). This information could have been used as a warning for the upcoming Global Financial Crisis (GFC) amongst other things.

The question of whether the market was rational was also answered as the application of appropriate tests showed that the model was characterised by rational expectations. It was found that expectations about changes in office building development fulfilled the requirements of efficiency and consistency. This implied that for the office market, since the expectations relating to office building development were rational, that the estimated model incorporates all available information, and that the efficiently incorporated information is consistently applied to future time-periods.

Tsolacos and McGough (1999) also found that a rule of learning was implied by the model which resembled the hypothesis of adaptive expectations. Expectations were revised in a proportional way, linked to the most recently observed error i.e. investors learned from their mistakes by incorporating past errors in their past expectations into their future expectations for investment outcomes. The paper concluded that the London office markets penchant for overbuilding could be cited by observers as an

example of irrational behaviour. However, overbuilding is not always an indication of irrational behaviour as developers respond to economic conditions they have perceived and deliver the space they think is required.

Tsolacos and McGough (1999) further concluded that when taking development decisions, developers and investors may not realise (and are thus unable to incorporate) the possible impact of future shocks (which are largely unpredictable). These shocks, such as the GFC, could have a negative effect on demand. An effect which it would be impossible to anticipate even by rational economic agents. Moreover, collective response and imperfect information about the developments undertaken by other developers, coupled with the indivisibility and irreversibility of building development, will also lead to an excess provision of space. Thus, a possibility of something like the GFC could not be incorporated into investor decision making, leaving them vulnerable to these shocks.

Chapter 3.2 The significance of this Chapter

Throughout this chapter the author has illustrated how the published work continued to develop the analysis and knowledge of the property markets in the UK. Having quantitatively characterised the markets in chapter 2, chapter 3 shows a consistent stream of work which helped provide depth of understanding into what drives the markets and how the markets interact and respond.

The development and planning models produced research which helped to inform developers, investors and the government by the provision of relevant insight into where markets are going and the implications of certain actions, both via economic signals and government legislation. This was partly used to drive government policy in this area.

Tsolacos, McGough and Thompson (2005) also illustrated how investors need to consider the wellbeing of their tenants (at least in the industrial sector) and consider affordability, while **Tsolacos and McGough (1999)** raised issues of uncertainty and volatility, whilst providing a clear link of the research to mainstream economic and financial theory.

The research highlighted strengths and weaknesses of the market. It is able to learn, to some extent, from its mistakes. However, the paper also highlighted how the market is unable to incorporate changes in risk and uncertainty occurring in the present or being foreseen for the future, as occurred during the GFC. This work was to be later expanded on in chapter 5.

Chapter 4 International Modelling and Market Comparisons

Property Publications in this chapter.

The following papers are submitted in this chapter concerning international modelling and market comparison.

Paper 2 – D'Arcy E., McGough T. and Tsolacos S., (1997a) "An empirical investigation of retail rents in five European cities", *Journal of Property Valuation and Investment*, **15** (4), p308-322. **Highly Commended by Emerald Publishing.**

Paper 3 – D'Arcy E., McGough T. and Tsolacos S., (1997b) "National economic trends, market size and city growth effects on European office rents", *Journal of Property Research*, **14**(4), p297-308.

Paper 4 – D'Arcy E., McGough T. and Tsolacos S., (1999) "An econometric analysis of forecasts of the office rental cycle in the Dublin area", *Journal of Property Research*, **16**(4), p309-21.

Paper 14 – McGough T., Tsolacos S. and Olkkonen O., (2000) "The predictability of office property returns in Helsinki", *Journal of Property Investment and Finance*, **18**(6), p565-585.

Paper 1 – Connell-Variy T. and McGough T., (2020) "An examination of house price movements in Australian resource communities", paper submitted and presented in the referred section of the 26th Pacific Rim Real Estate Society Conference, Canberra, Australia.

Chapter 4.1 Modelling International Markets

Whilst the author had begun by researching the UK market, as the research became more in-depth there was, of course, academic curiosity as to whether the research findings were UK centric or more generally applicable. Some findings had been different from those in the US (**McGough and Tsolacos, 1999**) so there was no guarantee that the findings would simply be duplicated across the European continent, for example. On top of this, there was great private sector investor interest as well with the growth of international property funds. This would lead to, for example, the first ever paper forecasting the Finnish market (**McGough, Tsolacos and Olkkonen, 2000**).

In 1997 a pair of papers began analysing the retail and office markets across cities within Europe (**D'Arcy, McGough and Tsolacos, 1997a and b).** In **D'Arcy, McGough and Tsolacos (1997a)**, the author wrote a paper that represented the

first systematic attempt to develop an econometric model of retail rent determination across European cities. The paper looked at the drivers of retail rents in five major European retail centres – Amsterdam, Brussels, Hamburg, London and Paris – over the period 1980 to 1994. The study was instigated by the conspicuous lack of research on the determinants of retail rents which, as was noted in the paper and mentioned in summary in chapter 2, was surprising given the increased prevalence of international investment activity in retail property.

D'Arcy, McGough and Tsolacos (1997a) produced a theoretical model of retail rent determination based on the inclusion of broad demand side influences. This built on the work of **McGough and Tsolacos (1995**a **and b)** in quantifying the drivers of the retail market. Subsequently, the model estimated a preferred specification for each of the five markets examined. A time series, cross-sectional methodology, similar to panel analysis, was developed to examine the main drivers in the five markets. Further analysis was carried out to highlight country specific influences on rental movements.

While accepting the localized nature of retail markets, **D'Arcy, McGough and Tsolacos (1997a)** illustrated that, despite this, there were broad factors that influenced retail markets generally across the five European cities looked at. On top of this it highlighted where and why differences occurred. Furthermore, as the cities examined were all, to some degree, international centres that attracted multinational retail occupiers and investors, the analysis provided a useful benchmark for the comparison of rental change between prime locations in key cities. Table 4 summarizes the univariate results from the paper and highlight the different lags and variable significance in the different cities. While having some similar drivers, each city also had unique timing and influences the authors had to adapt to for the models.

As Table 4 shows, the models demonstrated the importance of GDP as a determinant of retail rents in all five cities. However, differences were found in the timing of its significance, with contemporaneous changes most important in Hamburg and Amsterdam, and lagged changes more important in Brussels, London and Paris. Of the two specific retail variables compared only Paris had

consumer expenditure as the most significant variable, with all other cities finding retail sales to be the more significant.

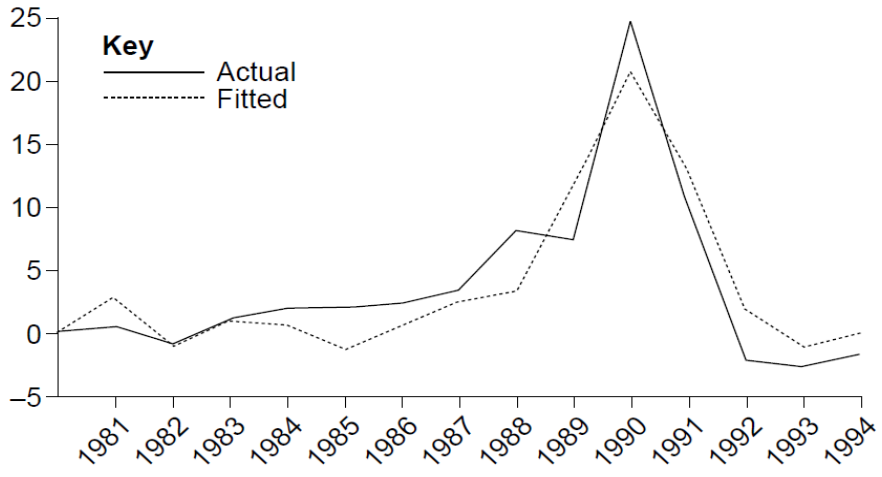
Table 4. Summary of Results

Variable	Changes in real rents: London		Paris		Amsterdam		Hamburg		Brussels	
ΔGDP	4.29	**0.42**	1.87	**0.07**	4.93	**0.73**	2.35	**0.63**	0.4	**–0.05**
	(3.2)*	*2.18*	(1.4)	*1.45*	(5.2)*	*2.31*	(4.8)*	*2.72*	(0.6)	*2.04*
ΔGDP(–1)	3.43	**0.30**	3.75	**0.49**	1.42	**0.19**	0.18	**–0.08**	1.77	**0.23**
	(2.6)*	*1.62*	(3.7)*	*2.31*	(2.0)**	*1.09*	(0.2)	*2.66*	(2.2)*	*2.25*
ΔGDP(–2)	1.25	**–0.03**	4.90	**0.50**	–0.19	**–0.08**	–0.6	**–0.04**	1.69	**0.15**
	(0.8)	*1.1*	(3.7)*	*1.50*	(0.1)	*0.67*	(0.7)	*2.65*	(1.8)**	*2.25*
ΔEX	5.96	**0.55**	1.90	**0.10**	3.60	**0.52**	1.76	**0.66**	NA	
	(4.1)*	*2.89*	(1.6)	*1.42*	(3.9)*	*1.02*	(5.1)*	*2.17*		
ΔEX(–1)	4.93	**0.46**	2.58	**0.32**	1.14	**–0.02**	–0.23	**–0.01**	NA	
	(3.5)*	*1.58*	(2.7)*	*1.77*	(0.8)	*1.06*	(0.4)	*2.44*		
ΔEX(–2)	1.08	**–0.05**	1.55	**0.06**	0.10	**0.08**	–0.41	**–0.04**	NA	
	(0.6)	*1.11*	(1.4)	*1.23*	(0.1)	*0.69*	(0.7)	*2.73*		
ΔRS	3.71	**0.37**	0.50	**0.06**	2.31	**0.61**	1.65	**0.24**	0.62	**0.04**
	(2.9)*	*2.55*	(1.4)	*1.40*	(4.6)*	*1.45*	(2.3)*	*3.09*	(1.2)	*2.1*
ΔRS(–1)	4.22	**0.75**	0.81	**0.14**	1.56	**0.28**	1.63	**0.22**	0.65	**0.05**
	(6.3)*	*1.92*	(1.8)**	*1.28*	(2.5)*	*1.46*	(2.2)*	*3.30*	(1.3)	*2.0*
ΔRS(–2)	1.70	**0.06**	0.36	**–0.04**	0.80	**0.01**	0.05	**–0.08**	0.17	**–0.08**
	(1.3)	*1.41*	(0.7)	*1.22*	(1.1)	*0.85*	(0.0)	*2.59*	(0.3)	*1.85*

Notes:
Estimation period 1981-94
* Significant at the 5 per cent level
** Significant at the 10 per cent level
NA = not available

Source: D'Arcy, McGough and Tsolacos, 1997a

Figure 6. Results for Paris Retail



Source: D'Arcy, McGough and Tsolacos, 1997a

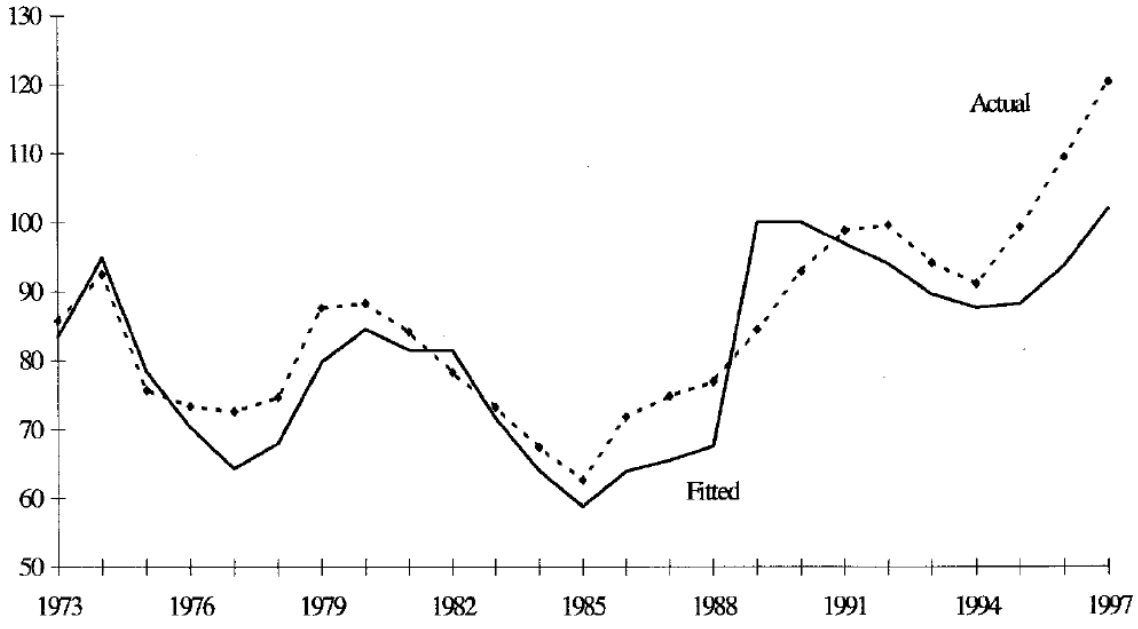
D'Arcy, McGough and Tsolacos (1997a) also provided charts (such as Figure 6) of each city model to provide readers with illustrations of the model accuracy, along with diagnostic tests. Given this was the first time such work had been attempted it was important to show what could be done. The findings of **D'Arcy, McGough and Tsolacos (1997a)** thus highlighted the fact that, while there was a broad set of similar drivers impacting the markets there were subtle differences in the individual markets. This was important to both investors and developers who would need to take into account a range of drivers when making retail investment and development decisions across these markets. This paper was **Highly Commended** by Emerald – the publishing house considering all the 1997 publications of the journal.

D'Arcy, McGough and Tsolacos (1997b) continued this analysis across Europe, but this time in the office market. The paper once again extended the existing research on European office markets by using a similar time-series cross-sectional methodology. However, for this paper the author looked at 22 contrasting European cities to compare the impact of national economic conditions, market size, growth measurements and city specific economics between 1982–94.

The paper started with a base model of real office rents constructed using national real GDP and real short-term interest rates based on the findings in the UK of previous work by the author (such as **McGough and Tsolacos, 1995a and b**). Also included was the investor equation from the work in **Tsolacos, Keogh and McGough (1998).** The paper confirmed these variables as significant drivers of rental changes across all the cities studied. This highlighted how the previous work discussed in chapters 2 and 3 could be translated internationally. The model was then extended to examine the influence of the size of the city, economic growth and changing city economics. It found that such variables were not significant determinants of office rents in the cities and further confirmed the importance and relevance across Europe of the author's previous work in the UK. A further implication of the study was that local factors appeared to be less important influences on rental determination relative to national factors in the cities examined. This was highly enlightening to international investors who could use previous research with confidence in new investment markets.

Besides considering inter-market linkages via a cross-sectional approach to markets the author also considered specific markets of interest. This was to examine issues in-depth to ensure consistent results, as well as to satisfy individual and investor interest and curiosity. **D'Arcy, McGough and Tsolacos (1999)** produced an econometric analysis of office rents in Dublin. This was a much smaller European market than previously considered and was examined between 1970–1997. Using a single demand and supply model it was found that incorporating changes in real GDP lagged one period and changes in the office stock lagged three periods were the main drivers of the market. It was also found that forecasts based on the model outperformed those from alternative statistical methodologies such as double exponential smoothing and the Holt–Winters procedure. This once again showed the transferability of the author's previous findings to disparate markets, and also how applying these findings consistently outperformed previous naive models. Figure 7 provides an illustration of the accuracy of the model produced.

Figure 7. Actual and fitted Dublin office rent index



Source: D'Arcy, McGough and Tsolacos 1999

The paper extended the existing quantitative research on European office markets by **D'Arcy, McGough and Tsolacos (1997b)** which had considered major markets over a shorter time period. Furthermore, the results obtained clearly demonstrated

the validity of using a correctly specified model to explain rental change, even in the context of a small market like Dublin.

D'Arcy, McGough and Tsolacos (1999) thus demonstrated the suitability of a single equation demand-supply interaction model for rent forecasting. This implied there was less need for information such as vacancy rates if a full demand supply model was available. It also highlighted to investors and developers the capabilities of econometric models to develop medium term forecasts to help with investment decisions.

This trend in considering often overlooked areas was continued in **McGough, Tsolacos and Olkkonen (2000).** This was the first ever econometric model and forecast of the Helsinki office market. The paper forecast the office property returns in Helsinki CBD using both short-run and long-run econometric specifications. Using real economy, monetary and financial market indicators a successful model was created. The paper was as much an illustrative piece of work to show analysts how to develop and select models based on common diagnostics criteria and ex post forecasting evaluation tests. The findings of the work were similar to those in **D'Arcy, McGough and Tsolacos (1997a, b and 1999)** with GDP in Finland being the key variable for modelling and forecasting office property returns in Helsinki.

A particularly unique result in this paper was concerning the relevance of GDP. Though it remains the strongest variable, it is not very strong in the 1970s. This was linked to the very regulated market in commercial real estate when rents were 'set in the sauna' not in the market place. As the market freed up the usual suspects became significant. This highlighted the importance of a free market to be present for an economic based econometric model to work. Only then will the usual interactions between dependent and independent variables take place and be able to be measured. **McGough, Tsolacos and Olkkonen (2000)** was very important for Finnish and international investors and was presented by the author with a translator and fully translated version in Finnish (once again a first for an econometric paper in Finland) to the Finnish investment community.

Connell-Variy and McGough (2020) continued this work of analysing specific individual markets to this day. In this paper a more specific issue was considered. It

aimed to show the impacts of a resources boom on housing in a small set of mining towns. An issue of particular relevance in Australia.

In an earlier coal boom, housing markets in Queensland mining towns were uniquely affected. For a short period of time the mining towns in Queensland shared in the fortunes of the mining industry. However, as the boom came to its peak mining companies changed their housing policies.

Companies started putting up their miners in camps not providing vast sums to pay rent to investors who had entered the market and bought up houses at often very inflated prices. This meant that following the end of the boom, housing prices fell back even more sharply than the coal prices. They also did not share in the resurgence of the industry in more recent years. This was clearly illustrated and highlighted in the paper by the huge error terms on the models post the late 2000s cycle compared to previous periods of the model. There was also the use of dummy variables which highlighted the direct impact (in 2009 and 2010) on house prices, when the mining camps started to be established by the mining companies.

Connell-Variy and McGough (2020) added to a growing body of research focused around the positive and negative impacts of mining on communities. It explored in detail the relationships that existed between house prices and commodity prices in a town closely linked to a particular industry or activity. This highlights and quantifies an issue which has been occurring for centuries from such events as gold rush towns and the coal mining centres within the UK in the 1970s and 1980s. It is posited in the paper that such research is utilised by governments to work more closely with all stakeholders in developing and managing future resource projects.

Chapter 4.2 The significance of this Chapter

Chapter 4 illustrates the continued expansion of academic work by the author in the field. Having developed structures and analysis of the UK market in the preceding chapters the author expanded this work internationally. Using panel data style analysis this continued across the retail and office markets of Europe to show the application of the author's findings across a wide array of possible markets.

Besides analysing many of the major European markets, the author then also examined specific smaller markets or markets considered more unique to check that the findings could be applied across all types of investment markets. This was important as it showed the applicative nature of the work for investors wishing to use this work to aid in investment and development in the private sector. It was also useful to guide other academics working within the field outside the UK. The winning of awards within the academic publishing field **(D'Arcy, McGough and Tsolacos, 1997a)** and special presentations without **(McGough, Tsolacos and Olkkonen, 2000)** highlight the importance of the expansion of the authors work from UK specific to international.

Chapter 5 International Pricing and Investment

Property Publications in this chapter.

The following papers are submitted in this chapter concerning international pricing and investment.

Paper 13 - McGough T. and Tsolacos S., (2001) "Do Yields Reflect Property Market Fundamentals?" *City University Business School Real Estate Finance and Investment Research paper* No. 2001.01 March.

Paper 18 - McGough, T. and Burston, B., (2009) "DTZ's Fair Value Estimates – Methodology and example", https://www.propertyweek.com/dtzs-fair-value-estimates-methodology-and-example/3148112.article

Example of a BCA Report

Paper 19 - BCA Research Global Real Estate Strategy May 2013 - Stable Income, Right Price.

Paper 20 - BCA Research Global Real Estate Strategy February 2014 – One Rate to Rule Them All

Paper 7 - McGough T. and Berry J., (2020a) "Pricing risk in yields and its impact on real estate market volatility", *Journal of Property Investment and Finance* (Forthcoming).

Paper 8 - McGough T. and Berry J., (2020b) "Pricing risk and its impact on real estate markets in Europe and Asia", paper submitted and presented in the referred section of the 26th Pacific Rim Real Estate Society Conference, Canberra, Australia.

Chapter 5.1 International Pricing and Investment

As the author was developing international models of rents and construction cycles, interest widened to the greater international investment environment. **McGough and Tsolacos (2001)** presented an analysis of yield modelling, a particularly difficult area of modelling due to the rapid movement in capital markets. The paper specifically hoped to investigate the relationship and links between capital markets and property markets. It examined the drivers between yield movements and other capital market variables to consider if the underlying property market was responsible for movements in yields, or if it was the wider investment market.

The paper progressed capital asset pricing models (CAPM) work which had been carried out in the finance world and also within commercial real estate. This was

compared to more generic real estate analysis of the markets. US research was ahead of UK research in this field at the time due to better data availability and a longer history of research in the area. Consequently, US models were the ones mainly considered, such as Sivitanidou and Sivitanides (1999) which looked at office capitalization rates across metropolitan locations. Their findings that there were local effects, time variant local effects and national economic effects impacting yields, linked in with the author's previous work highlighted in chapters 3 and 4.

The drivers of rental growth in a standard yield model linked in to the CAPM analysis and built on work done by Brown and Matysiak (2000) allowing the development of a yield model linked to government bonds and rental growth models. Once the models were specified **McGough and Tsolacos (2001)** aimed to test the forecasting capability of property yield models. The literature mentioned earlier, had proffered several approaches. The paper analyzed three models, a standard regression analysis, an ARIMA model and a VAR. Evaluating the forecast results showed that no single model outperformed consistently. ARIMA models of yields provided the most accurate forecasts and a regression model of yields the least accurate. However, in the second ex post forecast period the ARIMA was the worst performing model and the regression model the best.

McGough and Tsolacos (2001) highlighted that there were serious issues still needing to be considered in modelling yields, and that the simplistic approaches of a basic CAPM model were not sufficient for forecasting yields in a complex capital markets environment.

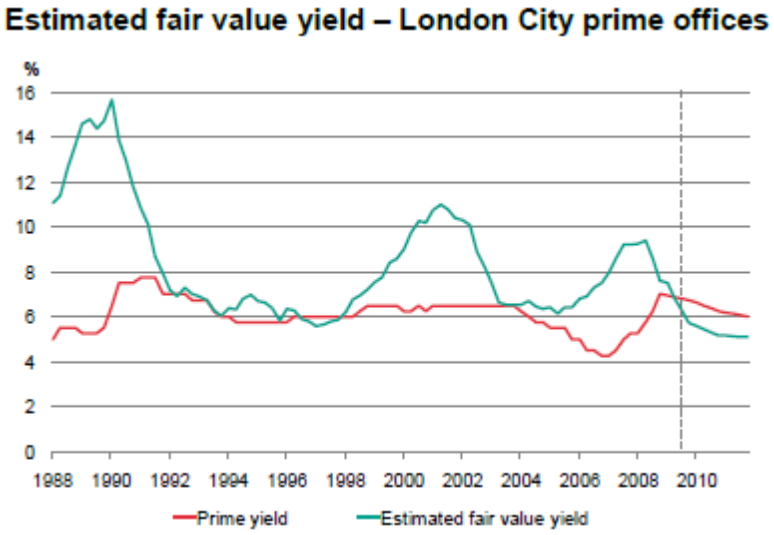
As the author returned to the private sector more applicative work was carried out. The author continued developing both international rental and yield models, this culminated in the work with DTZ to develop a Fair Value Index model. This combined expectations for rental growth and yield movement in order to advise investors on market pricing around the world. By combining forecasts of rents and yields in different sectors it was possible to forecast total return expectations for property. This could then be compared to expectations for government bonds. The methodology was launched in 2009. **McGough and Burston (2009)** developed an index to work out a pricing system based on longer term forecasts for rents and yields. The analysis assessed the fair value of commercial real estate by first looking at the returns an

investor could expect in the relevant market (office, retail and industrial) over 5 years, given the yield currently available in the market and likely future capital growth, driven by the combination of rental growth and changes in yield. Most importantly the analysis then took account of depreciation, transaction costs, the relative illiquidity of property and the risk arising from the uncertainty inherent in future property returns, to compare the expected property return relative to a 'risk-free' government bond investment. The report looked at the expected returns from property compared to the required returns to compensate for the cost of investing in property compared to a government bond. The research was carried out globally for all the major markets covered by DTZ.

McGough and Burston, (2009) and the consequent reports that flowed from it provided the first ever forward-looking, fully transparent comparative analysis of property versus other investment assets. It combined the author's knowledge of both modelling international rental markets and the knowledge gleaned about modelling yields (price). By being forward looking it enabled investors to attempt to get ahead of the curve. It also started to take into account the fact that the price of risk in the capital market was not a fixed figure but varied through time – something the author came back to later in this chapter. This became particularly significant in light of the GFC and the after effects of it.

Consequently, the first report in 2009 **(McGough and Burston, 2009)** highlighted the fact that while everyone was wary about investing in property prices had fallen so much that they had in fact fallen below fair value in the London City office market. This was illustrated by what became a standard for presenting value, as shown in Figure 8.

Figure 8. Fair Value pricing for London



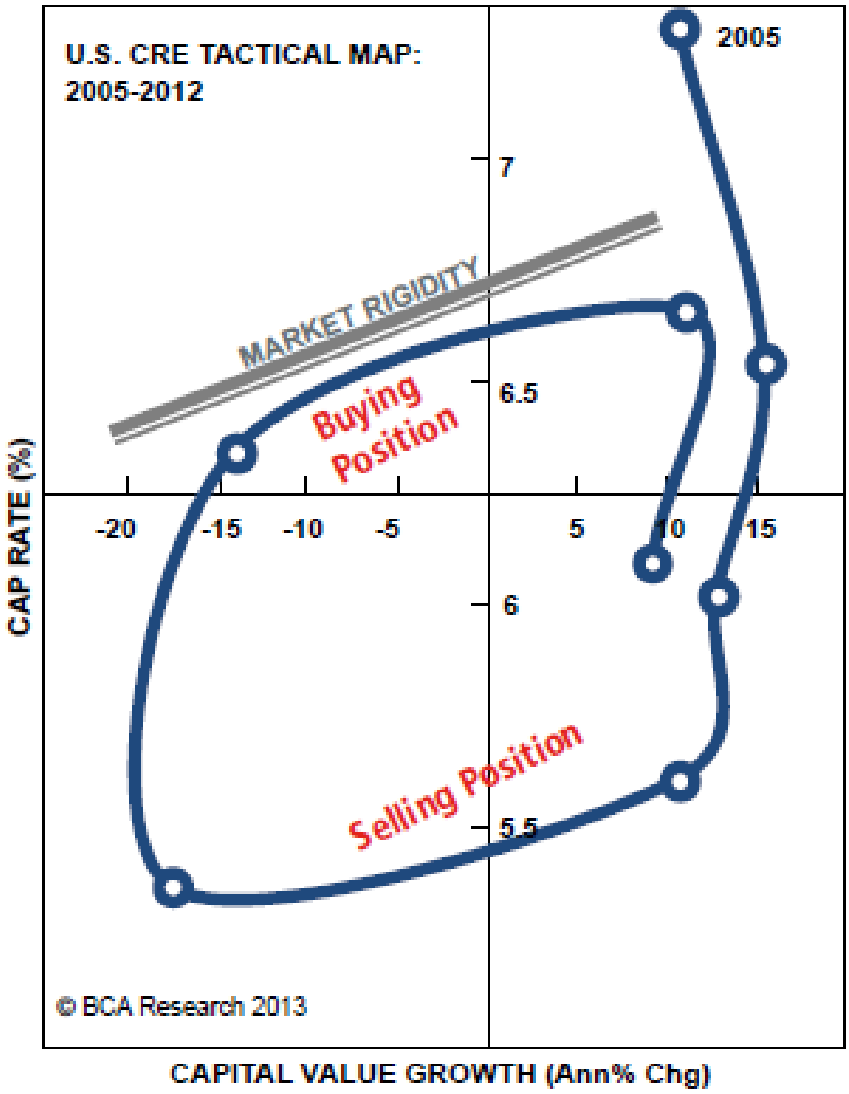
Source: DTZ Research, McGough and Burston 2009

By back tracking the analysis, the report also highlighted that the London market had been over priced for the past ten years, since the mid-1990s. Back testing the analysis also showed that the Index would have warned investors of the over-priced market up to 18 months before the GFC using forecasts available at that time. The analysis was very well received by the industry. Though not presented in a referred journal article it was attributed to opening up the analysis and improving investor knowledge of the real estate market. The, report made the front page of the Financial Times, (Thomas D., (2009) "City of London property slump first to reach point of good value". *Financial Times*, June 8, p1.) and the author was interviewed on BBC Business Lunch, Radio 4 Finance Today and CNBC Squawk Box to name but a few outlets. The Index became a main indicator for the market and is still used today by Cushman & Wakefield.

The author then moved to BCA Research – an investment research house based in Montreal – as their Global Real Estate Strategist to create a brand-new offering for the market. BCA research are a private research house for international investors. While continuing to research investment markets, all this work was privately sold to investors (at a considerable price). The papers were not referred, however the author continued to research in a similar vein. Examples of the work include **BCA Research Global Real Estate Strategy May 2013 - Stable Income, Right Price**. This was the first publication out. It introduced a whole new set of indicators for analyzing property

performance as well as discussion around property cycles. Figure 9 illustrates some of the analysis graphically.

Figure 9. Example of work at BCA Research



Source: BCA Research, The Author, 2013

The monthly papers reviewed a wide variety of commercial real estate angles once again based around their relationship with other assets. In **BCA Research Global Real Estate Strategy February 2014 – One Rate to Rule Them All** the author considered the change in the U.S. government bond and its composition into growth expectations and term premiums. It showed that a recent rise in bonds would not necessarily lead to a rise in commercial real estate yields. Highlighting that growth expectations remained low, this implied that there was no inflationary pressure going forward for the economy and that capital rates would not be under pressure.

Figure 10. Example of work at BCA Research

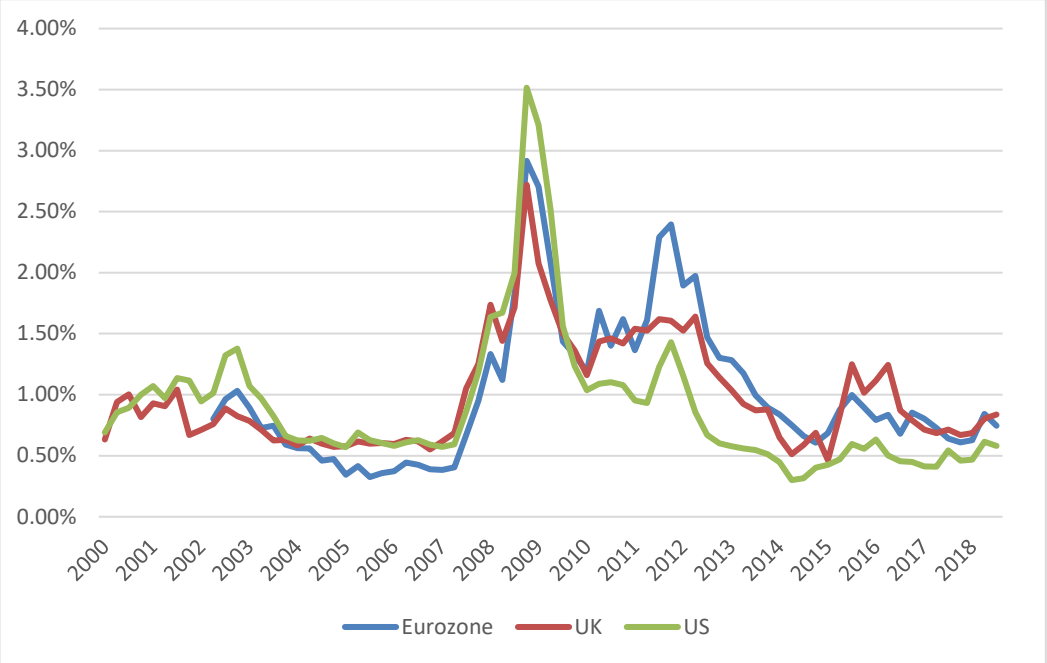
Source: BCA Research, The Author, 2014

Over the two years the product was being published, the papers were all of an investment ilk. Given they were not referred or freely available on-line the author leaves these papers as evidence of continued directional flow of research only.

Having left BCA Research, the author returned to academia and continued the analysis of pricing of commercial real estate and the issue of risk relative to other investment assets. **McGough and Berry (2020a)** explicitly considers the pricing and volatility of risk within the investment market. Developing a model for the pricing of risk, which had first been considered whilst at DTZ, the author created a variable to value and incorporate sentiment and risk into the modelling of the commercial real estate markets.

Within the paper, the author created a measure for looking at the spread of corporate bond rates compared to government bond rates to examine the appetite or the 'price' of extra risk, (through the spread). For each series, **McGough and Berry (2020a)** took the average spread over time and used this as a benchmark against which to gauge whether the spread at any point in time was above or below its normal level. This standardized the price of risk for each bond grade versus government bonds and from this a relative pricing of risk at any one time could be created. This analysis was then split geographically to provide a UK, European and Global Risk price sentiment indicator, as shown in Figure 11.

Figure 11. Risk Multipliers - Sentiment Indicators for Different Geographical Areas.

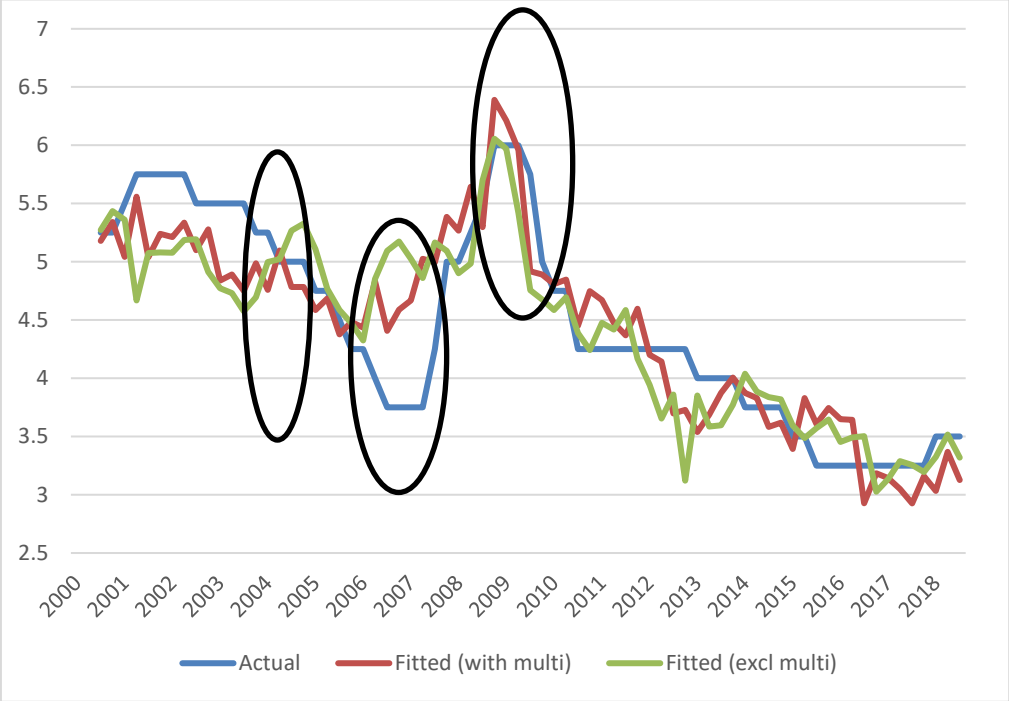


Source: MGough and Berry, 2020a

This information on the pricing of risk via the three risk multiplier series was then incorporated into an already created yield model for London and the impact of adding

the variable was compared. Figure 12 highlights the improvement in the models, particularly at the points where there is high volatility in the capital markets; volatility the real estate market is slow to pick up on.

Figure 12. Yield model comparisons from **McGough and Berry (2020a)**



Source: MGough and Berry, 2020a

McGough and Berry (2020a) found the use of measurements of market sentiment and risk provide a more powerful tool for modelling yields than previous techniques alone. It was felt that this would be of particular use in very volatile times and during periods where the signals from government bond markets (with negative bonds etc.) were confused. The paper was only based around one city as an indicative proposal. However, the findings indicated that, whilst more conventional models may end up in a similar place pricing wise, the dynamics of the market mean risk models may highlight mispricing in the short to medium term. There was thus the possibility that this offered investors early advice on clear buying/selling opportunities. There would also be the opportunity to understand why pricing of certain markets defies often clear and apparent economic signals which point in a different direction.

Following on from the reception of **McGough and Berry (2020a)**, the analysis was expanded and developed further by **McGough and Berry (2020b).** Once again, the

paper specifically considered the modelling of commercial property pricing in relation to the appetite for risk in the financial markets. However, this paper expanded on **McGough and Berry (2020a)** to examine the scope for using national and international risk pricing relative to specific cities within Europe and Asia.

The paper examined whether there was a different impact between different sized cities, both international and regional. The paper expanded the risk multiplier across Asia and developed yield models, with and without risk pricing multipliers, to consider its impact in a variety of markets. Table 5 provides a summary of the results.

Overall the paper showed that in principle the use of the risk multiplier could be expanded across international markets. However, a one size fits all measure may not work, particularly when dealing with capital markets. Whilst the European zone may well have a group of very similar economies, Asia was much more diverse in terms of financial markets, economic progress and culture.

However, it highlighted, once again, that investors should be using more intricate measures to identify under or overpricing of markets than the basic assumptions from CAPM models.

Table 5. Summary of Location Results for McGough and Berry (2020b)

										R-bar Sqrd	ADF of Errors
Brussels	Equ 1	5.24	+	0.31*GB	+	-0.18*Inf(-1)	+	-0.12*GDP(-1)		0.39	-2.58
	t statistic	22.50		5.11		-2.19		-1.99			**(0.09)**
	Equ 2	4.75	+	0.30*GB	+	-0.23*Inf(-1)	+		0.47*EU Multi	0.45	-2.62
	t-statistic	18.85		5.15		-2.90			2.35		**(0.08)**
Leeds	Equ 1	5.29	+	0.27*GB(-1)	+			-0.15*GDP(-1)		0.33	-2.69
	t statistic	15.22		2.99				-2.30			**(0.08)**
	Equ 2	4.08	+	0.31*GB(-1)	+	-0.16*Inf(-1)	+		1.19*UK Multi(-1)	0.50	-2.58
	t-statistic	11.02		4.40		-1.63			4.48		**(0.10)**
London	Equ 1	3.78	+	0.49*GB(-1)	+			-0.13*GDP		0.62	-2.65
	t statistic	21.24		10.73				-3.74			**(0.08)**
	Equ 2	2.61	+	0.52*GB(-1)	+				0.86*Global Multi	0.72	-2.60
	t-statistic	12.31		13.00					6.54		**(0.10)**
Marseille	Equ 1	4.53	+	0.83*GB(-1)	+	-0.26*Inf				0.73	-2.40
	t statistic	22.97		13.04		-2.23					**(0.12)**
	Equ 2	5.37	+	0.80*GB(-1)	+			-0.22*FBO	-0.74*EU Multi	0.77	-2.57
	t-statistic	18.73		15.59				-2.87	-4.09		**(0.10)**
Paris	Equ 1	3.08	+	0.63*GB(-1)				-0.31*FBO(-1)		0.79	-2.93
	t statistic	15.01		11.80				-4.29			**(0.05)**
	Equ 2								**N.S.**		
	t-statistic										
Melbourne	Equ 1	5.38	+	0.57*GB(-1)		-0.24*Inf		-0.24*FBO		0.56	-3.13
	t statistic	16.30		8.96		-2.59		-2.83			**(0.03)**
	Equ 2								**N.S.**		
	t-statistic										
Shanghai	Equ 1	-0.45	+	0.73*GB		-0.49*Inf(-1)		0.65*GDP(-1)		0.57	-2.80
	t statistic	-3.59		2.19		-5.54		9.88			**(0.06)**
	Equ 2								**N.S.**		
	t-statistic										
Singapore	Equ 1	2.20	+	0.79*GB(-1)	+	0.17*Inf		-0.03*GDP		0.34	-4.22
	t statistic	5.73		6.02		3.70		-1.69			**(0.00)**
	Equ 2	3.10	+	0.71*GB(-1)	+	0.21*Inf		-0.07*GDP	-0.64*Asia Multi(-1)	0.39	-4.02
	t-statistic	6.09		5.53		4.46		-2.83	-2.58		**(0.00)**
Sydney	Equ 1	5.26	+	0.39*GB(-1)	+			-0.25*FBO(-1)		0.44	-1.45
	t statistic	15.30		7.65				-2.85			**(0.55)**
	Equ 2	4.04	+	0.38*GB(-1)	+				0.48*Global Multi	0.45	-1.70
	t-statistic	13.58		7.55					3.03		**(0.43)**

Source: MGough and Berry, 2020b

Chapter 5.2 The significance of this Chapter

Chapter 5 illustrates the rapid expansion of the author's work both in the academic sector and its application and relevance to the private sector as well. Building on the researching of markets across Europe in chapter 4 the author was able to create pricing models knowing the main drivers of growth (a major requirement for CAPM models). On top of this the previous work led to this being internationalised across markets around the world.

Once the principle of accurate yield modelling had been established (**McGough and Tsolacos, 2001)** its application across European markets and wider afield was clear. From this flowed directly the path breaking DTZ Fair Value Index, **(McGough and Burston, 2009)** which required the capability of consistent and accurate models of rents and yields and an understanding of the workings of the financial and capital markets. Its importance is highlighted by the wide media attention the application of the ideas got in the UK and further afield. The expansion in to further indicators of real estate during the work at BCA, though not in the public domain, highlights the authors continued development of this knowledge.

BCA Research Global Real Estate Strategy February 2014 – One Rate to Rule Them All highlights the authors continued investigations into pricing commercial real estate markets and also risk. This was presented in a more academic format with **McGough and Berry (2020a and b)**, which once again applied the knowledge gained through market stylised facts and yield modelling to look further at the importance that the money markets take in pricing real estate. These papers spelt out new, innovative ways to look at risk, and thus understand the nuances of the real estate markets internationally.

Chapter 6 Forthcoming Work and Conclusion

The author is continuing to expand the ideas which have been flowing through this submission. The latest paper under the series McGough and Berry is titled "Evidence for structural breaks and floors to commercial real estate yields." This paper looks at the limitations to the CAPM model as government bonds tend to zero. It combines rational expectations into the commercial real estate yield modelling to provide analysis of how low and high prime yields can go.

Similarly, the next Connell – Variy and McGough paper "Mining industry growth and property demands: Impacts on the Brisbane office market" further expands the recent working on mining towns to examine the spill over impact on to major commercial office markets. The author thus continues to expand the area of work that has been discussed within the previous five chapters.

The area of commercial real estate investment is a major field of importance within the property capital markets and indeed the wider economy. The publications submitted within this thesis illustrate how, through original thought, rigorous analysis and methodology, and application of theory, the author has made a major contribution to the field of real estate research from 1995 to the present day. Whilst chapters 2-5 provide stand-alone examples of the author's cutting-edge research in specific categories, it is the whole body of the research which provides the totality of the impact. The overall significance is much more than the sum of the parts.

Chapter 2 provided a bedrock of defining how the property cycles work and how to effectively measure and model it. This included papers which helped define the relationship between finance, economics and real estate, linkages which are still used today. Chapter 3 built on this to provide a rich vein of research into the functioning of the markets within the UK. The papers helped to define the modelling techniques, tests and analysis within the field. They provided ground breaking findings concerning how the markets interacted and their rationality. This forward-thinking research had implications for the GFC and beyond, thus still being relevant today.

Other papers also provided new ways to analyse sectors of the commercial market. The results of these original approaches produced award winning papers and were

used by the UK Government in relationship to the regulation of planning in terms of commercial real estate and thus impacted the whole UK commercial real estate market.

Widening this out to an international environment in chapter 4 increased its impact into one of global scale. The papers have set the mark for analysing markets around the world based on further award-winning work and led industry to start setting up bespoke presentations of this work, in for example Helsinki. The papers used there are still seen, once again, as the basis for analysis in the market.

The movement to incorporating pricing into a multi-asset comparing model increased the applicative nature of the work as shown in chapter 5. This began analysis of risk which the author continues to look at today, whilst still broadening the knowledge of specific real estate markets. This work brought the author to international attention, as witnessed by the investment media. This highlights once again the relevance of the work and its impact on the investment world.

The research remains as relevant today at both a national and international level. The work is still incorporated into private sector reviews of the market and within the academic sector the papers remain regularly cited. Contemporary work in the field by the author and other academics is based off the work in this submission.

In the financial environment which we are in today, the knowledge of risk, market volatility, cycles and rationality remain just as relevant as they did when the work was written. The significant advances made by the author concerning the drivers and general dynamics of the commercial real estate market are essential knowledge for investors.

The papers include further analysis into how other disparate markets are developing, with the latest work applying the techniques to compare Asian to European markets, once again showing the continued relevance and importance of the research in this field. This portfolio of work retains contemporary relevance and significance to the real estate investment world.

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Examples of Private sector papers for consideration

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